

1 WHAT IS CLAIMED IS:

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3 1. A micromachined vertical vibrating gyroscope comprising:

4 a) an outer single crystal silicon assembly consisting of a plurality of arc-
5 shaped anchors that are arranged in a circle and extended from a single crystal silicon
6 substrate coated with an insulating annulus thereon, each of at least four anchors supporting
7 an outer suspended flexure at the center of its inner edge and two perforated and suspended
8 stops at the two sides of its inner edge and each of the anchors supporting a suspended comb
9 on its inner edge having a plurality of side fingers;

10 b) an intermediate single crystal assembly consisting of a suspended
11 vibrating wheel that has a same center with said circle formed by said arc-shaped anchors,
12 and supports a plurality of suspended combs on its outer edge which have a plurality of side
13 fingers, and connects to the outer anchors through the outer suspended flexures; and

14 c) an inner single crystal silicon assembly consisting of a suspended and
15 perforated vibrating hub that has a same center with said circle formed by said arc-shaped
16 anchors, and is divided into two electrically isolated and area-equal half-hubs, and is
17 connected to the vibrating wheel through two inner suspended flexures that are arranged
18 along the central symmetric line of the hub.

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20 2. The micromachined vertical vibrating gyroscope of claim 1 further comprising
21 an electronic control means for driving said vibrating wheel into rotational vibration, which is
22 adapted to be lateral comb capacitors formed from the parallel electrodes attached to the side
23 fingers of said combs extending from said anchors and said wheel respectively.

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1 3. The micromachined vertical vibrating gyroscope of claim 1 further comprising
2 an electronic sensing means for detecting the rotational vibration of said vibrating hub caused
3 by a combination of the rotational vibration of said vibrating wheel and an input angular rate,
4 which is adapted to be two twin vertical capacitors formed from the parallel electrodes
5 attached to the bottom of said vibrating hub and the interior top surface of said substrate
6 respectively.

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8 4. The micromachined vertical vibrating gyroscope of claim 1, wherein said
9 insulating annulus has an inner portion comprising silicon dioxide and silicon nitride.

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11 5. The micromachined vertical vibrating gyroscope of claim 1, wherein said
12 insulating annulus has an outer portion comprising oxidized porous silicon.

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14 6. The micromachined vertical vibrating gyroscope of claim 1, wherein said single
15 crystal silicon includes vertical epitaxial growth single crystal silicon and lateral overgrowth
16 single crystal silicon.

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18 7. A method for fabricating a micromachined vertical vibrating gyroscope
19 comprising steps of

- 20 a) providing a lightly doped single crystal silicon substrate;
- 21 b) forming a heavily doped buried layer in the substrate;
- 22 c) forming an insulating ring on the surface of the substrate;
- 23 d) performing selective epitaxial growth to form a vertical epitaxial single
24 crystal silicon layer on the exposed silicon surface of the substrate and a lateral overgrowth
25 single crystal silicon layer on the insulating ring;

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1 e) conducting first deep reactive ion etching to form first trenches in the
2 vertical epitaxial layer;
3 f) filling up the first trenches with an insulating material(s);
4 g) conducting second deep reactive ion etching to form second trenches in
5 the vertical epitaxial layer;
6 h) performing anodization to convert the buried layer into a porous silicon
7 layer;
8 i) removing a portion of the porous silicon layer to form suspension
9 structures;
10 j) conducting pre-deposition with a diffusion source;
11 k) conducting post-diffusion in oxygen atmosphere to form a heavily doped
12 single crystal silicon layer on the surfaces of the suspension structures and turn the rest of
13 the porous silicon layer into an oxidized porous silicon layer;
14 l) performing low pressure chemical vapor deposition to form an insulating
15 layer on the surfaces of the suspension structures; and
16 m) depositing a metal layer on the top surfaces and sidewalls of the
17 suspension structures.

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19 8. The method for fabricating a micromachined vertical vibrating gyroscope of claim
20 7, wherein said insulating ring comprises silicon dioxide and silicon nitride.

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22 9. The method for fabricating a micromachined vertical vibrating gyroscope of claim
23 7, wherein said insulating ring has a width ranging from 8 to 60 micron.

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25 10. The method for fabricating a micromachined vertical vibrating gyroscope of claim
26 7, wherein said vertical epitaxial layer has a thickness ranging from 5 to 40 micron.

